Due Date: July 15, 2008

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

In re Application of:	)	
	)	
Inventors: Hughes Marchand et al.	)	Examiner: Matthew J. Song
	)	
Serial #: 09/922,122	)	Group Art Unit: 7852
	)	
Filed: August 3, 2001	)	Appeal No.: _____
	)	
Title: METHOD OF CONTROLLING STRESS IN GALLIUM NITRIDE FILMS DEPOSITED ON SUBSTRATES	)	

REPLY BRIEF OF APPELLANTS

MAIL STOP APPEAL BRIEF - PATENTS
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

I. INTRODUCTION

In accordance with 37 C.F.R. §41.41, Appellants' attorney hereby submits the Reply Brief of Appellants in response to the Examiner's Answer dated May 15, 2008.

No fee is required for filing this Reply Brief. However, the Office is authorized to charge any necessary fees or credit any overpayments to Deposit Account No. 50-0494 of Gates & Cooper LLP.

II. ARGUMENTS

In the Answer, the Examiner essentially reiterates the prior rejections, but also includes new arguments using somewhat different citations to the references. In this regard, this Reply Brief of Appellants incorporates by reference herein the entirety of the previously filed Brief of the Appellant. Moreover, additional arguments are also presented below.

A. Arguments directed to the first grounds for rejection: Whether claims 1-2, 4-9, 15-17, 35 and 38 are anticipated under 35 U.S.C. §102(e) by U.S Patent No. 6,765,240 by Tischler et al. (Tischler).

1. Independent claim 1.

On pages (3)-(4), the Examiner's Answer sets forth the following:

Claims 1-2, 4-9, 15-17, 35 and 38 are rejected under 35 U.S.C. 102(e) as anticipated by Tischler et al (US 6,765,240).

Tischler et al disclose a semiconductor film of M*N formed on a substrate. Tischler et al also disclose using a silicon substrate (col 4, ln 50-60 and col 8, ln 10-35) and the M*N can be a single crystal material comprising a compositionally graded ternary metal nitride selected from the group consisting of AlGaN and InGaN (col 13, ln 1-5), this reads on appellant's single crystal graded gallium nitride layer having a substantially varying composition of a substantially continuous grade from an initial composition to a final composition.

With regard to the graded gallium nitride layer that has a net compressive stress, it is inherent to Tischler et al that the graded gallium nitride layer has net compressive stress because the differences in the lattice constant throughout the graded layer on a silicon substrate inherently cause compressive stress. Also, Tischler et al disclose that a single crystal has no defects from thermal coefficient of expansion differences, i.e. cracks (col 12, ln 45-65 and col 13, ln 1-5), which is further evidence that there is a net compressive stress because appellant discloses that crack free graded GaN has a net compressive stress, note page 8, lines 1-10 of the specification.

Furthermore, appellant discloses that a larger amount of compressive strain is present using appellant's method than is found when using other methods (See page 8, lines 1-5 of appellant's specification); therefore appellant essentially admits that other methods produce compressive strain, but that appellant's method merely produces more compressive strain, which supports the examiner's inherency argument that the graded layer taught by Tischler et al has a net compressive strain. Also, appellant teaches the compressive strain is large enough to counterbalance the tensile stress induced by the cool down such that the net stress in the epitaxial layer is compressive. (See page 8, lines 1-5 of appellant's specification). Appellant's disclosure further supports the examiner's inherency position because tensile stress, which is counterbalanced by the compressive stress which is induced by cooling down; however, Tischler et al are relied upon for teaching the compressively stressed material at high temperature. Thus, there is no tensile stress to counterbalance the compressive stress by cooling down.

On pages (6)-(9), the Examiner's Answer sets forth the following:

(10) Response to Argument

Arguments directed to claims 1-2, 4-9, 15-17, 35 and 38

The primary issue to resolve is whether Tischler et al.'s silicon substrate and graded epitaxial layer would inherently possess a net compressive stress. The Examiner's position is that Tischler et al.'s silicon substrate and graded epitaxial inherently has a net compressive stress because the methods of forming the structure is similar to appellant's method of formation and based on appellant's disclosure of the properties of a net compressive stress the epitaxial layer.

Also, Tischler et al.'s epitaxial layer is graded, thus, has a lattice mismatch which appellant also uses to form compressive stress. Appellant also discloses that compressive strained films do not crack, and Tischler et al.'s epitaxial layer is also crack free. It should also be noted that the Examiner's rejection is based on the intermediate product taught by Tischler et al. Tischler et al. teach a silicon substrate and a graded epitaxial layer formed thereon, then the silicon substrate is removed after growth to produce a free standing epitaxial layer. The rejection is based on the structure taught by Tischler et al. prior to removing the silicon substrate.

Appellant's argument that Tischler et al. would not inherently have a net compressive stress because the substrate is present only at the growth temperature (or close to it) is noted but not found persuasive. (See pg 5 of the brief). Appellant alleges that removing the substrate at high temperature eliminates the problem of thermal expansion mismatch between the substrate and the epitaxial layers, so it is expected that a free standing M*N film are stress free; however, appellant's invention is directed to a conventional film stack. First, this argument is not persuasive because removing the film at high temperature does not change the relationship of thermal expansion coefficients. The effect might be less but the epitaxial layer will still be subjected to stress because of the different thermal expansion coefficients of the substrate and the epitaxial layer. Second, Tischler et al. do teach that the substrate can be removed at more than 100°C below the growth temperature, preferably within 300°C; thus some added compressive stress would have resulted from the cool down to the removal temperature. Third, Appellant discloses the tensile stress is induced by the cool down procedure (See page 8, lines 1-5 of appellant's specification). Tischler et al. teach the silicon substrate and graded layer present at the growth temperature without a cool down process; therefore, the tensile stress which needs to be counterbalanced by the compressive stress is not induced since there is no cool down process; thus, there is inherently a net compressive stress. Fourth, Appellant discloses compressively strained films do not crack. (See page 8, line 5 of appellant's specification). Tischler et al. teach a substantially defect free (crack free because cracks are a defect) epitaxial M*N layer; thus the epitaxial layer inherently has a net compressive stress. Finally, Appellant achieves the claimed net compressive stress by varying composition continuously between the initial composition and the final composition without any interruption in precursor supply, and Appellant also discloses this method produces a larger amount of compressive strain than found when using other methods. (See page 7, line 28 to page 8, line 3). Similarly, Tischler et al. teach ternary species of precisely graded AlGaN by controlling the

composition by the gas phase composition during growth (column 7, lines 10-20 and claim 6). Therefore, a similar method is expected to produce a film having a net compressive stress, and Appellant discloses that other methods also are known to produce compressive stress.

Appellant's argument that the GaN layer deposited on a Si substrate has a net compressive stress after the structure has cooled down and the free-standing GaN layer taught by Tischler et al. should be stress free is noted but not found persuasive. First, deposition at a high temperature is still expected to produce a compressive stress because of the relationship between the thermal expansion coefficients and lattice constants of the epitaxial layer and the substrate. Second, Appellant does not address Tischler et al.'s teaching that removal of the substrate is typically conducted within 100°C of the growth temperature or at a temperature more than 100°C below the growth temperature. (column 8, lines 30-45). Therefore, Tischler et al. do teach cooling the structure after growth and prior to removal; thus, the structure would inherently have had a net compressive stress because appellant also teaches compressively strained films do not crack and Tischler et al. teach an epitaxial layer which is defect free, where cracks would be a defect that are not present in Tischler et al.'s epitaxial layer (See page 8, line 5 of appellant's specification and column 5, lines 10-37 of Tischler).

Appellant's argument that nothing in appellant's paragraph [0025] supports the conclusion that there is a net compressive stress in Tischler et al.'s intermediate product at the growth temperature is noted but not found persuasive. (See pg 7 of the brief). First, the Examiner admits that the Examiner relies on Appellant's disclosure for providing the rationale for establishing inherency. However, the reliance is entirely based to show that an inherent feature is present, not as a teaching of prior art; thus the use of Appellant's disclosure is proper. Second, Appellant merely alleges that nothing in Appellant's paragraph [0025] supports the conclusion that there is a net compressive stress; however, the Examiner has clearly provide ample rationale in support of inherency, as discussed previously. Also, Appellant does not address the Examiner's position that the epitaxial layer is defect free after cooling 300°C from the growth temperature, which further supports the Examiner's inherency position. Appellant merely directs the arguments to the intermediate structure at the growth temperature. Appellant has not met the burden of showing an unobvious difference as required by MPEP 2112 after the Examiner presented reasoning tending to show inherency in the substantially identical products.

In summary, Tischler et al teach a graded epitaxial layer formed on a silicon substrate, and the Examiner has provided multiple rationales based on Appellant's disclosure which supports the Examiner's inherency position. Appellant's arguments are not persuasive and fail to rebut the Examiner position of inherency, as required by MPEP 2112. Also, Appellant fails to address Tischler et al.'s teachings of cooling the grown layer up to 300°C below the growth temperature and still producing a defect free epitaxial material, which based on Appellant's disclosure requires a net compressive stress. (See page 8, lines 1-5 of Appellant's specification).

Appellants' attorney respectfully disagrees with this analysis. With regard to the Answer's general assertion that Tischler's intermediate result inherently has a net compressive stress, because Tischler's method is similar to Appellants' method, Appellants' attorney respectfully disagrees. Tischler's method is different from Appellants' method, and thus Tischler's intermediate results are different from the structure recited in Appellants' claims.

With regard to the Answer's assertion that Tischler's semiconductor film has a substantially continuous grade, Appellants' attorney respectfully disagrees. Tischler's method is different from Appellants' method, and thus results in a different structure from the structure recited in Appellants' claims. Note that Appellants' specification teaches combining a buffer layer and a GaN layer into a single deposition step without any interruption in the precursor supply, to produce Appellants' claimed structure (see Appellants' specification at paragraphs [0024]-[0025]). Tischler, on the other hand, describes the growth of a silicon buffer layer followed by a gallium nitride layer where there is an interruption in the precursors during the growth process (see Tischler at col. 6 lines 44-64), which would result in a structure that is not a substantially continuous grade, unlike the structure recited in Appellants' claims. Thus, it cannot be inferred that the structure resulting from Tischler's method is the same structure as recited in Appellants' claims.

With regard to the Answer's assertion that Tischler's graded gallium nitride layer inherently has a net compressive stress, because the differences in the lattice constant throughout the graded layer on a silicon substrate inherently cause compressive stress, Appellants' attorney respectfully disagrees. Appellants' attorney notes that there is no evidence to support the conclusion that the intermediate results of Tischler, comprising the graded layer on a silicon substrate, cooled to only 100-300°C below the growth temperature in the range of 800-1300°C (see Tischler at col. 6, lines 44-64 and col. 8, lines 33-45), has a net compressive stress. Certainly, none of the references support this conclusion; indeed, nowhere does the Office Action cite any references in support of this conclusion. In contrast, Appellants' specification describes cooling from ~1000°C to room temperature (see Appellants' specification at paragraph [0008]), which results in Appellants' claimed structure having a net compressive stress. It cannot be inferred, based on these different methods, that the intermediate result of Tischler's method is the same structure recited in Appellants' claims.

With regard to the Answer's assertion that Tischler discloses a single crystal that has no defects from thermal coefficient of expansion differences, i.e. cracks, which is further evidence that there is a net compressive stress, because Appellants disclose that crack-free graded GaN has a net compressive stress, Appellants' attorney respectfully disagrees. Nowhere does Tischler describe the lack of defects in its intermediate results, at a temperature 100-300°C below a growth temperature in the range of 800-1300°C, as being indicative of a structure having a net compressive stress, unlike the structure recited in Appellants' claims. Appellants' specification, on the other hand, states that the compressive stress in their claimed structure is large enough to counterbalance the tensile stress induced by the cool-down procedure such that the net stress in the epitaxial layers is compressive, and compressively-strained films do not crack. In Tischler, the substrate is removed at high temperature, there is no substrate present when the cool-down to room temperature occurs, and a free-standing epitaxial film at room temperature is not subject to thermal expansion mismatch, which means that it should be stress-free.

With regard to the Answer's assertion that Appellants' statement, in paragraph [0025] of Appellants' specification, that "a larger amount of compressive strain is present in the layer structure than is found when using other methods" is an admission that other methods produce compressive strain, Appellants' attorney respectfully disagrees. No such admission can be inferred. For example, Appellants' invention has larger compressive strain than a method that produces no compressive strain. In any case, the absolute amount of compressive stress is irrelevant, since Appellants' claims recite a net compressive stress, which is defined as the sum of the grown-in stress and the thermal mismatch stress, which should be compressive (see Appellants' specification at paragraph [0008]).

With regard to the Answer's assertion that Appellants teach that the compressive strain is large enough to counterbalance the tensile stress induced by a cool-down such that the net stress in the epitaxial layer is compressive, that Appellants' disclosure further supports the Examiner's inherency position because tensile stress is counterbalanced by compressive stress, which is induced by cooling down, and that Tischler is relied upon for teaching the compressively stressed material at high temperature, because there is no tensile stress to counterbalance the compressive stress by cooling down, Appellants' attorney respectfully disagrees. Nowhere does Tischler describe its intermediate result, at a temperature 100-300°C below a growth temperature

in the range 800-1300°C, as being a structure having a net compressive stress, unlike the structure recited in Appellants' claims.

With regard to the Answer's assertion that Tischler's semiconductor film on a silicon substrate, at high growth temperature, has net compressive stress because Tischler's film is subjected to thermal stress due to the different thermal expansion coefficients of silicon and the film, Appellants' attorney respectfully disagrees. Thermal stress, and consequently net compressive stress, is only induced by a change in temperature. Tischler's film at high growth temperature is not subjected to a change in temperature and therefore it cannot be inferred that Tischler's epitaxial layers have a net compressive stress at high growth temperature.

With regard to the Answer's assertion that Tischler's epitaxial layers inherently have a net compressive stress because Tischler describes a cool down (before removal of the substrate) in a manner similar to Appellants' method, Appellants' attorney respectfully disagrees. Tischler describes cooling to 100-300°C below a growth temperature in the range 800-1300°C, but nowhere discloses these intermediate results as having a net compressive stress, unlike the structure recited in Appellants' claims. Note that Appellants' specification describes cooling from ~1000°C to room temperature, which results in Appellants' claimed structure having a net compressive stress. It cannot be inferred, based on these different methods, that the intermediate result of Tischler's method is the same structure recited in Appellants' claims.

With regard to the Answer's assertion that Tischler's epitaxial layers have a net compressive stress because Tischler's epitaxial layers are defect free after cooling by 100-300°C, Appellants' attorney respectfully disagrees. Nowhere does Tischler describe the lack of defects at a temperature 100-300°C below a growth temperature in the range 800-1300°C as being indicative of a structure having a net compressive stress, unlike the structure recited in Appellants' claims. Note that Appellants' specification states that cracking only occurs once the tensile stress exceeds 400 MPa (see Appellants' specification at paragraph [0008]). Moreover, because tensile stress is proportional to temperature change, a crystal cooled by 300°C below a growth temperature in the range 800-1300°C may have very different defects than a crystal layer cooled from ~1000°C to room temperature. Thus, it cannot be inferred that the intermediate result of Tischler's method is the same structure recited in Appellants' claims.

In conclusion, Appellants' attorney notes that Tischler describes a substantially different method as compared to Appellants' method, and therefore it cannot be inferred that the

intermediate result of Tischler's method is the same as the structure recited in Appellants' claims, namely a semiconductor film, comprising a silicon substrate and a single crystal graded gallium nitride layer deposited on the silicon substrate having a varying composition of a substantially continuous grade from an initial composition to a final composition and a net compressive stress.

Thus, Appellants' attorney submits that independent claim 1 is allowable over the Tischler reference. Further, dependent claims 2, 4-9, 15-17, 35 and 38 are submitted to be allowable over the Tischler reference in the same manner, because they are dependent on independent claims, and because they contain all the limitations of the independent claims. In addition, dependent claims 2, 4-9, 15-17, 35 and 38 recite additional novel elements not shown by the Itoh reference.

2. Dependent claim 2, 4-9, 15 and 35.

Appellants' attorney respectfully submits that these claims stand or fall with independent claim 1, and thus are not argued separately.

3. Dependent claims 16-17

On pages (9)-(10), the Examiner's Answer sets forth the following:

> Appellants' argument that doping does not teach or suggest introducing one other element into the growth chamber for the graded gallium nitride layer causing no abrupt variations in the varying composition of the graded gallium nitride layer, wherein the other element is silicon is noted but not found persuasive. First, Tischler et al. teach a graded AlGaN or InGaN, and the material is doped with silicon. (See column 13, lines 1-10). Second, Tischler et al. teach doping during the growth to yield an n-type doping. (See column 8, lines 45-67). Tischler et al. do not teach doping with abrupt variations in the varying composition, thus, implicitly teaches avoiding abrupt variations. Finally, N-type doping of the M*N material during growth with Si, as taught by Tischler et al. in column 9-15, would require uniform doping to achieve uniform effect because if the dopant abruptly changes in the composition then the device would not function properly.

Appellant's attorney respectfully disagrees. The cited portions of Tischler merely refer to doping and compositionally graded compounds, but do not teach or suggest introducing one other element into the growth chamber for the graded gallium nitride layer causing no abrupt

variations in the varying composition of the graded gallium nitride layer, wherein the other element is silicon, indium or arsenic. Indeed, the cited portions of Tischler make no mention of avoiding abrupt variations in the varying composition.

4. Dependent Claim 38

With regards to dependent claim 38, which recites that the graded gallium nitride layer has a net stress below a stress required for crack generation in the graded gallium nitride layer, the Office Action asserts that these limitations are disclosed by Tischler, which shows that the GaN material has no defects from thermal coefficient of expansion difference. Appellants' attorney respectfully disagrees. As noted above, Tischler does not teach or suggest a structure similar to Appellants' claimed structure, because Tischler does not teach or suggest a structure that has a net compressive stress, in either the intermediate product or the end product.

B. Summary.

In summary, the Tischler reference fails to teach or suggest all of the elements of the Appellants' claimed invention. Further, the various elements of the Appellants' claimed invention together provide operational advantages over the disclosure in the Tischler reference. In addition, Appellants' invention solves problems not recognized by the Tischler reference. Consequently, Appellants' attorney submits that claims 1-2, 4-9, 15-17, 35 and 38 are allowable over the Tischler reference.

III. CONCLUSION

In light of the above arguments, Appellants' attorney respectfully submits that the cited references do not anticipate nor render obvious the claimed invention. More specifically, Appellants' claims recite novel physical features which patentably distinguish over any and all references under 35 U.S.C. §§ 102 and 103.

As a result, a decision by the Board of Patent Appeals and Interferences reversing the Examiner and directing allowance of the pending claims in the subject application is respectfully solicited.

Respectfully submitted,

GATES & COOPER LLP
Attorneys for Appellant

Howard Hughes Center
6701 Center Drive West, Suite 1050
Los Angeles, California 90045
(310) 641-8797

Date: July 15, 2008

By: /George H. Gates/
Name: George H. Gates
Reg. No.: 33,500

GHG/